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The Burning Rate and Flame Colour Effects of Various Binder Levels on Briquettes Produced from *Gmelina Aborea* Sawdust.

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quantities of binding materials on *Gmelina arborea* sawdust. Treatments were: T1 (100g G. *aborea*+25% starch+100ml of water) T2 (100g G. *aborea*+50% starch+100ml of water), T3 (100g G. *aborea*+75% starch+100ml of water and T4 (100g G. *aborea*+100% starch+100ml of water). The parameters considered were: the average time taken for each treatment to fully ignite, the time taken for each treatment to burn into Ash, the flame color produced by each treatment and the smoke colour produced by each treatment. From the analysis of the treatment, it was observed that a progressive increase in starch level from T1 to T4 resulted to increase in fully ignition time and decrease in time taken to burn to ash. Considering the flame colour and the smoke produced, there was a gradual change in smoke colour from T1 to T4, no difference in their flame colour, they all produced yellow flame. The result also showed that T1 (100g G. *aborea*+25%starch+100ml of water) has highest time taken to burn to ash (42mins), caught fire quickly and burnt with a little white smoke. This indicates that there is no need to increase the concentration of starch above 25%. It is therefore recommended that 25% starch level should be used for briquettes production using sawdust of *Gmelina arborea*.

Introduction

Rural households and minority of urban dwellers depend solely on fuel woods (charcoal, firewood and sawdust) as their primary sources of energy for the past decades (Onuegbu, 2010). Of all the available energy sources in Nigeria, coal and coal derivatives such as smokeless coal briquettes, bio-

coal briquettes, and biomass briquettes have been shown to have the highest potential for use as a suitable alternative to coal/ fuel wood in industrial boiler and brick kiln for thermal application and domestic purposes. Global warming has become an international concern. Global warming is caused by greenhouse gasses which carbon dioxide is among the major contributors. Increased emissions of CO₂ have been drastically increased owing to the fact that the rate of

Abstract

Every year millions of tons of agricultural wastes are generated which are either destroyed or burnt inefficiently in loose form causing air pollution. These wastes can be recycled and can provide a renewable source of energy by converting biomass waste into highly useful fuel briquettes. This recycled fuel is beneficial for the environment as it conserves natural resources. Today, renewable energy source of power generation has become very promising. The study aimed at determining the burning rate and flame colour of briquettes using varying

deforestation is higher than the rate of afforestation in Nigeria. Majority of the huge available energy materials are not suitable to be used directly as fuel without undergoing some scientific processing. This is probably as a result of inappropriate density and high moisture contents and these factors may cause problems in transportation, handling and storage. Most of these wastes are left to decompose or when they are burnt, there would be environmental pollution and degradation (Jekayinfa and Omisakin, 2005). Therefore, there is a need to convert these wastes into forms that can alleviate the problems they pose when used directly. An assessment of the potential availability of selected residues from maize, cassava, millet, plantain, groundnuts, sorghum, oil palm, palm kernel, and cowpeas for possible conversion to renewable energy in Nigeria has been made (Jekayinfa and Scholz, 2009).

As the population of the world continues to grow, the demand for energy is becoming a critical challenge for the world's energy leaders (Christoph, 2012). Global energy consumption has about doubled in the last three decades of the past century. In 2004, about 77.8% of the primary energy consumption was from fossil fuels (32.8% oil, 21.1% natural gas, 24.1% coal), 5.4% from nuclear fuels, 16.5% from renewable resources, of which the main one was hydro (5.5%) whereas the remaining 11% consisted of non-commercial biomasses such as wood, hay, and other types of fodder, that in rural economies still constitute the main resource (Oyedepo, 2012). With improvements in energy efficiency, it is expected that global energy demand doubles by 2050. This is the consequence of global population growth, global economic growth, continued urbanization, as well as the resulting increased demand on mobility and other energy dependent services (WEC, 2013).

Briquettes have many numerous uses which include both domestic and small industrial cottage applications (Ahmed *et al.*, 2011). They are often used as a development intervention to replace firewood, charcoal, or other solid fuels. This is because with the current fuel shortage and ever rising prices, consumers are looking for affordable alternative fuels and briquettes fill this gap for: Cooking and water heating in households, heating productive processes such as tobacco curing, fruits, tea drying, poultry rearing etc., firing ceramics and clay wares such as improved

cook stoves, pottery, bricks etc., fuel for gasifiers to generate electricity, powering boilers to generate steam.

The study was carried out to investigate the effect of different concentration of binder on combustion properties of briquette produced and the average time taken for each treatment to fully ignite and identify the flame color produced by each treatment.

Materials and Methods

The experiment was carried out at Ladoko Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. The sample *Gmelina aborea* sawdust was collected from the sawmill location of Ogbomoso North local government Area, Oyo State. The materials used were saw dust of *Gmelina aborea*, cassava starch, mixing containers, stirrer, weighing machine, bucket, measuring cylinder, water, stove, bamboo drying board, briquette mould, sieve of 3mm, nylon, spoon, pot and muslin cloth.

Cassava tubers collected in fresh form were washed, peeled, ground and pressed to extract the liquid content. The liquid was filtered with muslin cloth and the filtrate was allowed to stay for two hours so that the starch would decant from the mixture. The upper liquid layer was then carefully decanted and the sediment was mixed with boiled water to form starch.

A 2250 ml of water was measured with a measuring cylinder and poured into a kettle, and then the kettle was put on fire. Then, a 675 ml of starch was measured and diluted with 250 ml of water and the starch solution was stirred properly so as to form an even mixture. The boiling water on fire was then poured into the already prepared solution of starch in a bucket; a stirrer was used to turn the material properly for about 5-6 minutes so that it will not form clods.

Sawdust of *Gmelina aborea* was sieve with a sieve of 3 mm to obtain a uniform grain size distribution for the sample. Cassava starch was used as binder for the briquette and four starch ratios notably; 25%, 50%, 75% and 100% of the weights of sample were used to determine the effect of binder properties of briquettes produced. *Gmelina aborea* {100g} was mixed with different concentration level of binder as shown above under binder ratio.

T1 (100g *G. aborea*+25%starch+100ml of water)

T2 (100g *G. aborea*+50%starch+100ml of water)

T3 (100g *G. aborea*+75%starch+100ml of water)

T4 (100g G. aborea+100%starch+100ml of water)

Starch was used as the binder in this study. The prepared starch was added to each of the samples as shown under experimental design above. Then the mixture of the binder and the residues was stirred rigorously to ensure a proper mix. A cylindrical mould was used in producing the biomass briquettes. The cylindrical mould was turned upside down and the binder/residue mixture was fed into the lower part of the mould. The upper part of the mould was assembled, and the mould was placed in the space between the upper plate and the lower plate of the mould and compressed at a moderate pressure. The wet briquette was pulled out of the briquette mould gently into track dry board and dried for a month before use.

Results and Discussion

The table below shows the burning rate and flame colour of the briquettes produced.

Treatments	Time taken to burn to Ash (min)	Time taken to ignite (min)	Time taken to fully ignite (min)	Smoke produced by the briquettes	Flame characteristics
T1	42	5mins	8mins	Very little white smoke	Yellow Flame
T2	39	4mins 30secs	10mins	Little white smoke	Yellow Flame
T3	38	4mins 40secs	11mins	Little white smoke	Yellow Flame
T4	36	5mins	12mins	Little black smoke	Yellow Flame

T1 (100g G. aborea+25%starch+100ml of water)

T2 (100g G. aborea+50%starch+100ml of water)

T3 (100g G. aborea+75%starch+100ml of water)

T4 (100g G. aborea+100%starch+100ml of water)

The result indicates that starch has a significant effect on the burning rate and flame color of the briquettes. The increase in concentration of starch from T1 to T4 resulted to increase in full ignition time and decrease in time taken to burn to ash. Considering the flame colour and the smoke produced, there is a gradual change in smoke colour from T1 to T4, no difference in their flame colour, they all produced yellow flame which is detrimental to the environment.

The manually operated briquette machine consists of one mould with internal diameter of 55mm and a depth of 70mm. The machine consists of several parts which include mould, under plate, body frame, upper frame, mould brace, handle and a long metallic rod with a round metallic lid at the end. The handle is jointed with a long metallic rod of about 50cm which has a cylindrical lid-like structure at the end to compress the biomass during briquetting to form the cylindrical briquettes. The immovable mould is braced with upper frame. The whole machine is supported by 4 stands. The under plate of about 5mm is placed horizontally on the mild steel which is more thicker than under plate during compaction. After compaction, the under plate is gently removed to eject the briquette out from the mould.

The result also shows that T1 (100g G. aborea+25%starch+100ml of water) which has the highest time taken to burn to ash (42mins), caught fire quickly and burn with a little white smoke performed very well. This indicates that there is no need to increase the concentration of starch above 25% because the higher the concentration of starch from T1 to T4 resulted in decrease in time taken to burn to ash and increase in smoke which increases gradually until it get T4 which is completely black.

The yellow flame produced tells that incomplete combustion is taking place. It is never used to heat anything only to show that the flame source is on (www.homegnides.sfgate.com). Yellow colour

signifies inefficient combustion because other condensates are burning along with the methane. The condensate might include tar, dust or oil of which are potentially hazardous chemicals. For a

sustainable environmental management of African landscape, ardent conscious efforts should be deployed in the area of smoke control especially from fuel wood use.

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